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THE EFFECTS OF UNDERWATER SOUND ON MARINE ORGANISMS - A REVIEW.

by

10 Albert L. Brooks

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INTRODUCTION

In response to an inquiry regarding the effects of underwater sound on marine biological populations a cursory review of available literature was undertaken.

→ next page

ADMINISTRATIVE INFORMATION

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It was quickly discovered that only a limited amount of research has addressed itself to this problem. A fair number of papers, report studies of underwater sound on sharks and have been undertaken in an effort to discover a method of repelling or frightening sharks away from swimmers and divers. Other research has been directed toward the use of underwater sound for the capture of commercially important species of fish. Yet other studies have been oriented toward a more basic approach and have endeavored to increase our still imcomplete and largely empirical knowledge of phonoreceptive mechanisms.

The vast majority of this research has been conducted in relatively small tanks under controlled laboratory conditions. Few studies have been attempted in the open sea although science's repertory of recorded sounds of marine biological origin increases daily.

The ensuing review is divided into four parts. Each part considers a few of the papers dealing with studies of underwater sound and their affects on fish, sharks, mammals and invertebrates respectively. For additional references to any particular phase of the subject material the reader is referred to the bibliographies of the particular papers cited here.

I. Experiments with Fish

Several experiments have been conducted in an effort to attract or repel fish by playing back to the fish the sounds of feeding and schooling. The experiments have met with varying success. Some success in attracting fish with frequencies between 0.5 and 7 kHz is reported by Hashimoto and Maniwa, (1967).

Miyake (1952) attempted to attract or repel yellowfin tuna (Thunnus. albacores & little tunny (Euthynnus affinis) with continuous sounds from 100 to 70,000 Hz but achieved no positive results.

Iversen (1967), also working with yellowfin tuna reports that the fish responded to sounds from 50 to 1100 Hz, with the most sensitive responses occurring between 300 and 500 Hz.

Burner and Moore (1953) exposed rainbow (Salmo gairdneri) and brown trout (S. trutta) to sounds between 67 Hz and 70,000 Hz at intensity levels up to 82 dB (re 1 microbar). Similar studies were conducted by Moore & Newman (1956 in which juvenile salmonid were exposed to frequencies between 50 Hz and 20,800 Hz at sound pressures

up to 7200 dynes per sq. cm.. Results of both experiments led to the conclusion that there was no significant response to sound except for an initial "start" at the lower frequencies.

In another study of sound perception in teleosts, Wodinsky and Tavolga (1964) state "... the most sensitive frequency range for most fishes appears to be in the 300 to 800 cps region and few, if any species, can detect sounds above 3000 cps." In their experiments these authors used intensity levels up to about +40 dB more specifically, the authors found that the lowest thresholds of the squirrelfish (Holocentrus ascensionis) were at 800 cps at intensity levels of about -24dB (re 1 microbar). At 100 cps the threshold rose to +4dB, and at 2400 cps, the threshold level was at +35.5dB. In the blue-striped grunt (Haemulon sciurus), the thresholds at 1100 and 600 cps were about +43 and -4dB respectively.

II. Experiments with Sharks

In a study of sound perception in lemon sharks (Negaprion brevirostris), Wisby, et al. (1964) report that no sharks responded, at any intensity, to frequencies higher than 1000 cps, and that the number of sharks responding at each frequency decreased as the frequency increased.

Nelson et al. (1969) observed responses of three species of Bahamian sharks and three species of groupers to low frequency (50 - 200 Hz), pulsed sounds. According to these authors the [illegible]est sound was meant to simulate a struggling fish sound and [illegible]ed frequencies from 50 to 200 Hz (30 dB / octave attenuatio[illegible]de this range), pulse rates of 4 to 7 sec., pulse lengths of [illegible] to 0.25 sec., train lengths of 0.3 to 7 sec., and inter-train intervals of 0.7 to 10 sec.. Sound-pressure level of the projected signal was about 50 dB above 1 dyne / cm^2 at one meter, a level calculated to be detectable above ambient noise at distances of at least several hundred meters.

III. Experiments with Mammals

Johnson (1967) found that the lowest threshold of sound for the bottlenose porpoise (Tursiops truncatus) occurred in frequencies about 50 kHz at an intensity level of about -55 dB (re 1 microbar). below 50 kHz, thresholds increased continuously with decreasing frequency to a maximum of about -37 dB at 75 Hz. Above 50 kHz the threshold increased slowly to about -45 dB

at 100 kHz to about 35 dB at 150 kHz. 150 kHz was determined to be the effective upper limit of hearing for the experimental animal.

Schevill and Lawrence (1953) elicited response from the same species (i.e., Tursiops truncatus) from frequencies ranging as high as 153 kHz. According to Schevill (1964), "Mysticete (baleen whales) sounds are typically low frequency moans and screams, ranging in fundamental frequency from below 20 cps (Balaenoptera physalus) to near 1000 cps (Megaptera)." Sounds produced by the odontocetes (toothed whales) may be emphasized in different frequency bands but are usually below 30 kHz. Unfortunately we have no good figures for the intensity of Cetacean sounds.

IV. Experiments with Invertebrates

In a study by H. and M. Frings (1967) the reactions of specific marine invertebrates including representatives from three major phyla (Arthropoda, Coelenterata and Mollusca) indicate that in the animals tested little or no response occurred to frequencies in excess of 1000 Hz.

In experiments conducted on Lake Tanganyika in April, 1969, Jones and Brooks (1969) ran a series of hydrological and biological tests to determine the effects of 1.8 pound TNT explosive sound signals on the commercial fishery found there. They were unable to detect any dead fish resulting from a series of explosions detonated at 350 ft. depth and concluded that the blasts had no significant effect on fish species in the lake.

V. Conclusion

On the basis of present knowledge, and results of current research it seems reasonable to conclude that teleosts, some sharks, several invertebrates and probably most mysticete cetaceans are most sensitive to underwater sounds of low frequencies which may range from 20 Hz to 1000 Hz and on occasion perhaps to 3000 Hz. The odontocete, viz. the bottlenose porpoise and perhaps others, have an extremely broad range in hearing capabilities which may extend from below 75 Hz to slightly more than 150 kHz and exhibit their lowest threshold of sound in frequencies around 50 kHz.

In view of these considerations it seems highly probable that fixed transducers producing signals whose frequencies lie above 3 kHz would have little, if any, significant effect on resident marine populations.

A. L. Brooks
A. L. BROOKS

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